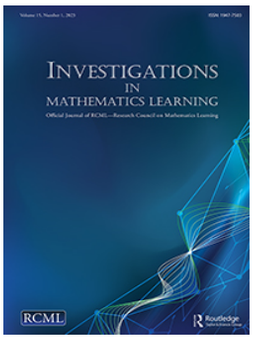

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Elementary Mathematics Specialists as Emergent Informal Teacher Leaders in Urban Schools: Engagement and Navigations

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ABSTRACT

This 5-year mathematics professional development project involves 27 elementary teachers prepared and supported as Elementary Mathematics Specialists (EMSs) in high-need, urban schools. The EMSs are a distinctive population as informal teacher leaders, with a primary responsibility of teaching students. Described here are data collected at the end of Year 1 via a survey of coaching practices, a teacher leader record, and individual and focus group interviews. The findings illuminate the variety of ways they were serving as a more knowledgeable other and practicing agency in this teacher leadership. They were agentic in their teacher leader efforts by navigating constraints through: focusing on incremental changes; developing collegial, trusting relationships with peers; and leaning into the network of teacher support in the project. The findings also provide insights into how their primary and concurrent role as teacher of students provided credibility and understanding with fellow teachers, contributing to affordances in their informal teacher leader capacity.

KEYWORDS

Elementary Mathematics Specialists; mathematics teacher leader; teacher leadership; coaching; professional development

Elementary Mathematics Specialist (EMS) preparation programs should have a two-fold emphasis: fostering expertise as a teacher of mathematics and as a teacher leader who serves as a more knowledgeable other, supporting colleagues' instruction and other efforts within mathematics education (Association of Mathematics Teacher Educators, 2013). Currently, 19 states and the District of Columbia have established routes for EMS licensure, certification, or endorsement, with 10 other states in the process of developing pathways (Elementary Mathematics Specialist & Teacher Leaders Project, 2022). Our state provides a K-5 Mathematics Endorsement (K-5 ME) and a Teacher Support & Coaching Endorsement (TSCE). The context of this study is a 5-year professional development project for 27 elementary teachers in high-need, urban schools who are prepared and supported as EMSs in part through completion of these two endorsement programs. Project goals include the development of EMSs who deliver effective and equitable mathematics instruction and serve as mathematics teacher leaders in a variety of ways, especially coaching.

Given the notable variability of EMS preparation programs across the USA (Elementary Mathematics Specialist & Teacher Leaders Project, 2022), there has been a call for "developing a knowledge base for the preparation of EMSs," including how "elements of an EMS program are necessary for productive outcomes" (Reys et al., 2017, p. 231). The outcome of teacher leadership, including how EMSs engage in coaching and associated practices, has not been widely studied (Yopp et al., 2019). There is a need for study of rigorous EMS preparation programs that align with standards and recommendations (Association of Mathematics Teacher Educators, 2013), so the field can develop

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shared understandings on what makes a difference in EMSs' preparation, particularly related to teacher leadership. This study aims to do just that by focusing on a robust EMS preparation program and specifically examining this salient outcome.

Further, because EMSs' ways of working are highly varied, driven in part by context and need (Baker et al., 2021; McGatha et al., 2015), studying the differing roles and responsibilities they assume is warranted in order to better understand the effective use of these professionals. For the EMSs in this project, their primary responsibility is teaching students, thus they are a distinctive population as informal teacher leaders. This contrasts with teacher leaders who are in formal capacities such as instructional coaches who primarily support teachers. These EMSs' informal teacher leader role holds differing responsibilities, challenges, and affordances, which are also inextricably bound and varied based on individual school context. There is a gap in the research on how EMSs navigate their leadership role (McGatha et al., 2015; Reys et al., 2017), with this study exploring constraints and the practicing of agency in their efforts, as well as affordances of an informal capacity. Further, this study's participants and context are important, as the EMSs are largely teachers of color, working in urban schools that serve students historically marginalized and underserved in mathematics education. At the time of this study, they had completed Year 1 of the project and were developing their understandings and capabilities as informal teacher leaders. Notably, this project's K-5 ME program has been extensively studied and shown to produce significant positive changes in participants' mathematical knowledge and beliefs, along with substantial implementation of effective and equitable instructional practices (e.g., Myers et al., 2021, 2020; Swars Auslander & Myers, 2022; Swars Auslander et al., 2019, 2018). This study extends the current body of inquiry by centering on teacher leadership. With focal participants of EMSs developing as informal teacher leaders during a mathematics professional development project, these questions guided the study: (1) How are the EMSs providing teacher leadership, including self-reported coaching practices?; and (2) What are the navigations related to their teacher leader efforts?

Related Literature and Perspectives

EMS Preparation Programs: Development of Teacher Leadership

The Association of Mathematics Teacher Educators' (2013) *Standards for Elementary Mathematics Specialists* serves as a guide for EMS preparation programs, with a focus on content knowledge for teaching, pedagogical knowledge for teaching, and leadership knowledge and skills. Programs should include a supervised internship with a range of learners, including elementary students and teachers. Learning experiences should be embedded in practice, with strong connections to EMSs' classrooms, schools, and/or school districts (Reys et al., 2017). When it comes to leadership knowledge and skills, specialized courses should prepare EMSs to "take on collegial, non-evaluative leadership roles within their schools and districts. They must have a broad view of the many aspects and resources needed to support and facilitate effective instruction and professional growth" (Association of Mathematics Teacher Educators, 2013, p. 8).

When considering EMSs' preparation as teacher leaders, there are a number of important understandings and capabilities to be developed (Association of Mathematics Teacher Educators, 2013). These professionals need knowledge of teacher development trajectories to create differentiated learning experiences and specific long-term goals for teacher growth (Costa & Garmston, 2016). Programs should foster capabilities for: developing trusting relationships with teachers, engaging in goal setting, asking productive questions, and providing continuous, targeted opportunities for collaboration and feedback. Further, programs should develop a deep knowledge of instructional practice and related theory and research, so EMSs can support teachers in making instructional decisions grounded in these understandings (Association of Mathematics Teacher Educators, 2013; McGatha et al., 2015). Broadly, program experiences should focus on: (a) effective ways of coaching teachers, such as cognitive coaching (Costa & Garmston, 2016), co-teaching (Gibbons & Cobb, 2017),

and modeling; and (b) planning, developing, facilitating, and evaluating effective professional development (Association of Mathematics Teacher Educators, 2013).

When considering states offering pathways for advanced specialist certification, there are notable differences in EMS preparation programs related to duration, number of course hours, course emphases, field practicum experiences, and delivery (Elementary Mathematics Specialist & Teacher Leaders Project, 2022; Spangler & Orvick, 2017). This variability is linked in part to differences in program goals and provides a warrant for research on EMS preparation programs. Researchers have largely examined participants' content knowledge, beliefs, instructional practices, and engagement in teacher leadership and coaching, as well as their perceptions of the program (Campbell & Malkus, 2011, 2014; Harrington et al., 2017; Kutaka et al., 2017; Myers et al., 2021, 2020; Nickerson, 2010; Swars Auslander & Myers, 2022; Swars Auslander et al., 2019, 2018). Evident are positive findings for beliefs and instructional practices and some mixed findings related to content knowledge. Campbell and Malkus (2011) inquiry involved a preparation program for EMSs (n = 24) who were formal instructional coaches logging their professional activities (though the central focus of the study was student achievement). They determined that the variability in time spent on activities was linked to contextual factors (e.g., demands of district assessments, requirements/requests of school administration), though most time was devoted to coaching teachers, preparing for teaching/coaching, supporting assessment, and engaging in personal professional activity. More inquiry needs to focus on the development of teacher leadership, including coaching, and how EMSs engage in and navigate this work in both formal and informal roles (Baker et al., 2022; McGatha et al., 2015; Yopp et al., 2019).

Framings for This Project

The EMS preparation program in this project is grounded in conceptual framings and research on the preparation of EMSs and on mathematics teacher education, professional development, and instruction (Association of Mathematics Teacher Educators, 2013, 2017; Bartell et al., 2017; Carpenter et al., 2015; National Council of Teachers of Mathematics, 2014, 2020). Moreover, the EMSs' engagement in collaborative, practice-based professional development is grounded in Wenger's (1998) conceptualization of communities of practice, which has been defined as groups of people who share a concern or a passion for something they do and learn how to do it better as they interact. Central to this is the more knowledgeable other (Vygotsky, 1978), which refers to anyone who has a better understanding or a higher ability level than the learner, with respect to a particular task, process, or concept. The more knowledgeable other is normally thought of as being a teacher, coach, or older adult, but can also be a peer. As the EMSs engage as a community of practice within this project, with more knowledgeable others including course instructors, the program director, school leadership, and even one another, this should support their development as effective and agentic mathematics teachers and teacher leaders.

EMSs: Roles and Responsibilities

EMSs' specific roles and responsibilities vary (Baker et al., 2021) and are dependent upon the contextual needs and plans of schools, school systems, and states (McGatha et al., 2015). For example, they may provide enrichment or remediation instruction for small groups of students, or they may teach mathematics to all students in a grade (Association of Mathematics Teacher Educators, 2013; Webel et al., 2017). Or, they may primarily work as coaches of teachers, focused on supporting instructional improvements and a school's mathematics program as a whole (Campbell & Griffin, 2017; McGatha et al., 2015). They may also support the development of their state's standards, curricula, and assessments, along with serving on committees that shape mathematics education policies and practices (Association of Mathematics Teacher Educators, 2013).

Within these wide-ranging responsibilities, EMSs' work as a teacher leader often involves coaching other teachers, which can occur in a variety of one-on-one and group contexts. Based on review of extant studies, McGatha and colleagues (2015; 2017) 2015posited that coaches' ways of interacting

with individual teachers are on a continuum from more-directive (e.g., modeling lessons, providing resources) to less-directive (a process of collecting data from observed lessons, providing feedback, and engaging teachers in thought reflection), with the latter more powerful for prompting teacher change. Relatedly, a systematic review of research (Gibbons & Cobb, 2017) illuminated potentially productive activities for mathematics coaches. Activities with groups of teachers include engaging in the discipline, examining student work, analyzing classroom video, and participating in lesson study, while those with individual teachers include co-teaching and modeling instruction. There are several coaching models evident in the extant literature (Yopp et al., 2019). Cognitive coaching, which was emphasized in this project, is a particularly powerful approach that relies heavily on coaches' use of reflective questions to encourage teachers to refine their professional knowledge base, emphasizing the cultivation of self-assessment and self-direction and a collaborative partnership between a coach and mentee (Costa & Garmston, 2016). This approach to supporting instructional change stands in contrast to top-down teacher evaluation systems founds in most schools, with a body of research on cognitive coaching illuminating positive outcomes for teachers, students, administrators, and school climate (Edwards, 2021).

Some studies have documented EMSs' work as teacher leaders and coaches (e.g., Chval et al., 2010; Mudzimiri et al., 2014; Whitenack et al., 2014), though focal participants were largely in formal instructional coach roles rather than informal capacities. For example, Chval et al. (2010) determined that novice, formal instructional coaches' (n = 14) work focused on supporting teachers, assisting students, supporting the school-at-large, and spending time on their own professional learning, with considerable differences between participants in how much time was devoted to these four components. No matter the role, the work of teacher leaders and coaches holds complexity, as research has identified a number of constraints they must navigate, including organizational and social factors (Blazar, 2020; Hannan & Russell, 2020; Hashim, 2020; Hopkins et al., 2017). There is a need for more research on how EMSs in various teacher leader roles engage in and navigate this work (McGatha et al., 2015; Yopp et al., 2019). In these navigations, agency is essential. Agency has been defined as the willingness and capacity to act according to professional values, beliefs, goals, and knowledge in the different contexts and situations that educators face in their work (Toom et al., 2015). It is constructed in context and changes as educators encounter the varying dilemmas and uncertainties inherent in the profession. Preparation programs (Bartell et al., 2019), including those for EMSs, have a responsibility to support the development of agentic teachers and teacher leaders, who have knowledge and strategies to persist and thrive in their work.

Methodology

This study used mixed methods, specifically a convergent parallel design, meaning that quantitative and qualitative data were collected concurrently, given equal priority, and integrated during the interpretation phase (Creswell, 2014). The inquiry occurred during the COVID-19 pandemic, and the researchers were mindful of this throughout.

Participants and Context

This study's context was a mathematics professional development project focused on the development of 27 elementary teachers as EMSs in high-need, urban schools. Multiple partners are involved, including a university, school district, and nonprofit organization. Project goals include the development of EMSs who deliver ambitious mathematics instruction and serve as mathematics teacher leaders in a variety of ways. The project also aims to promote equity and access in mathematics education, support teacher retention in high-need schools, and situate teacher candidates in a hiring pipeline. Since the EMSs' primary responsibility is teaching students, their role as a mathematics teacher leader is an informal one. The project is 5 years in duration and at the time of this study, the participants had completed 1 year and were emergent teacher leaders.

Teachers were selected to participate based on criteria that identified them as successful, experienced teachers of mathematics with aptitude for teacher leadership. The project's recruitment efforts had concentrated on the highest need elementary schools in the district, as determined by the federally-funded free and reduced lunch program rates. To be considered for the project, applicants submitted a variety of documents, including a resume, goals statement, letter of recommendation from a school administrator (that in part addressed student achievement in mathematics of the applicant), transcripts (minimum of 3.0 graduate GPA required), state-mandated teacher effectiveness score (minimum of proficient required), and a standardized test score focusing on mathematics. The Selection Team was composed of three university faculty, the project's program director, and two school district representatives, who conducted small group interviews with the applicants and thoroughly reviewed the application materials. These reviews focused on meritorious professional achievement, academic accomplishment, knowledge of mathematics, commitment to teaching mathematics, and evidence of/desire for teacher leadership. These criteria, plus consideration of race/ethnicity, gender, grade level, and school site with the aim of assuring participation of underrepresented groups and diverse school sites and grade levels, informed the selection of the 27 teachers in the project.

All participants were employed in a large, urban school district in the southeastern USA. They taught in 22 elementary schools, collectively serving 91% students of color, with the largest populations being 44% Hispanic and 36% Black; 69% of students were eligible for the federally-funded free and reduced lunch program. The participants self-described as 24 females and 3 males, with 70% self-identifying as persons of color (41% Black, 7% Hispanic, 7% Asian, 7% Hispanic/White, 4% Hispanic/Black, 4% Black/White). The average age was 39 years (range of 28–62 years). They were a highly educated group, with 100% having a master's degree and 33% holding an educational specialist degree. Further, they were experienced teachers, on average having 10.5 years of teaching experience (range of 5–22 years). Teaching positions varied and included: three kindergarten, one 1st grade, two 2nd grade, five 3rd grade, one 4th grade, seven 5th grade, four STEM/Math Specials, one English to Speakers of Other Languages, one Special Education, one Early Intervention Program, and one Accelerated Content. Of these participants, two taught in Dual Language Immersion settings, including Spanish (2nd grade) and French (5th grade). Within these differing grade levels and foci, all taught mathematics, including some for part and some for all of the day. Notably, this group of participants represents the diversity of teachers from which students learn mathematics in elementary schools.

The participants are prepared and supported through completion of a university's K-5 ME and TSCE programs during the first 2 years, along with participation in Professional Learning Communities (PLCs) and individual mentoring for the entire 5 years (see Table 1). The endorsement programs include four elementary mathematics content courses integrating pedagogy, one course focusing on teacher leadership and coaching, and two internship courses, with one emphasizing mathematics and the other coaching. Overall goals of both programs are development of: effective and equitable mathematics instructional practices (Carpenter et al., 2015; National Council of Teachers of Mathematics, 2014, 2020); deep and broad knowledge of elementary mathematics, including specialized content knowledge (Ball et al., 2008); productive mathematical beliefs and

Table 1. Timeline and project elements aimed at preparing and supporting EMSs.

Year 1		Year 2			
Fall 2020	Spring 2021	Summer 2021	Fall 2021	Spring 2022	Years 3–5
1 TSCE course (Teacher Leadership & Coaching) PLC and Mentoring	1 K-5 ME course (Number & Operations) PLC and Mentoring	1 K-5 ME course (Data Analysis & Probability, 2-week summer institute)	1 K-5 ME course (Algebra & Rational Number) and 1 TSCE course (the Internship) PLC and Mentoring	2 K-5 ME courses (Geometry & Measurement and the Internship) PLC and Mentoring	PLC and Mentoring

professional agency; and teacher leader capabilities, including coaching skills (Association of Mathematics Teacher Educators, 2013, 2017).

K-5 Mathematics Endorsement

In the K-5 ME program, the development of effective and equitable instructional practices focuses on learner-centered, responsive instruction (Carpenter et al., 2015; Jacobs & Empson, 2016) and the eight mathematics teaching practices in NCTM's *Principles to Actions* (National Council of Teachers of Mathematics, 2014). These include: (a) selection and implementation of instructional tasks with high levels of cognitive demand; (b) use of multiple representations and tools; (c) promotion of problem solving and reasoning, explanation and justification, and connections and applications typical of standards-based learning environments; and (d) use of children's thinking and understandings to guide instruction. There is explicit emphasis on equity-based, identity-affirming, justice-oriented pedagogy, including fostering of practices that provide access, support, and challenge in learning rigorous mathematics for every student (Association of Mathematics Teacher Educators, 2017). EMSs learn about planning for and enacting instruction that leverages children's mathematical, cultural, and linguistic resources/strengths, while nurturing positive student identity in mathematics (Aguirre et al., 2013; Association of Mathematics Teacher Educators, 2017; Bartell et al., 2017; National Council of Teachers of Mathematics, 2020, 2021). Learning during class sessions occurs through: (a) active engagement in and analysis of the mathematics in the elementary curriculum, especially through cognitively demanding instructional tasks; (b) study of children's thinking and learning via video clips and written work samples; (c) examination of classroom practice via video clips and written teaching cases; and (d) scrutiny of the research base on elementary mathematics education and of critical aspects of equity and access with connections to classroom practice and schools (e.g., culturally responsive teaching, instruction for multilingual learners, and teaching mathematics for social justice). There is a substantial focus on the professional development materials from *Cognitively Guided Instruction* (e.g., Carpenter et al., 2015) and *Developing Mathematical Ideas* (e.g., Schifter et al., 2018).

Teacher Support & Coaching Endorsement

The TSCE program has a concentrated focus on the EMSs' preparation as teacher leaders by developing their understandings of teacher development, coaching, and facilitation of professional development. It aims to develop: knowledge of adult learning and the continuum of teacher development across the career span; and coaching skills that support instructional change through cognitive coaching (Costa & Garmston, 2016), observations of classroom practice, analysis of student work, and examination of lesson components. The cognitive coaching cycle is an iterative process that includes a pre-conference focused on goal setting, followed by a lesson observation using specific data collection techniques, and then a post-conference involving sharing of data with connection to goals and actionable feedback, with the coach encouraging reflection and decision-making centered on the mentee's concerns. Coupled with cognitive coaching, there is a focus on coaching for equity, specifically a transformational approach (Aguilar, 2020) involving coaches and their mentees continual analysis of behaviors (what we do), beliefs (what we think), and ways of being (who we are). EMSs are immersed in these understandings and approaches during the first course, Teacher Leadership & Coaching.

Then, in the second course the EMSs apply their learning in an Internship focused on coaching a teacher candidate or novice teacher. With an understanding of adult learning and teacher development, the EMSs identify their coaching approach (Orlando-Barak & Wang, 2020) and adjust their style, as needed, to alleviate resistance and to promote mentee reflection and self-direction (Costa & Garmston, 2016). They develop a trusting relationship with their mentee, engage in goal setting, and provide continuous, targeted opportunities for collaboration and sharing feedback. The EMSs implement the cognitive coaching cycle at least three times across the course with their mentee, and also provide support through teacher development activities dependent on the differentiated needs of their mentees (e.g., curriculum and lesson plan support, data analysis focused on student learning,

modeling, co-teaching, video self-study). These coaching expectations are a model for coaching mentees across the project.

Professional Learning Communities and Individual Mentoring: Support for Teacher Leader Activities

In addition to preparation for teacher leadership in the endorsement programs, support for the EMSs as they serve as teacher leaders is provided through a PLC and individual mentoring, both facilitated by the project's program director. PLCs and individual mentoring focus on: building a community of learners within each PLC, augmented support for developing effective and equitable mathematics instruction, and targeted support for their selection and implementation of what is called in this project teacher leader activities. The three PLCs, with nine EMSs each, are clustered around grade levels/teaching focus and meet monthly eight times across the school year.

To lead instructional change and support wide-ranging improvements, the EMSs engage in a number of teacher leader activities across the 5 years in their school, district, community, and other contexts, applying their teacher leader understandings and capabilities learned in the K-5 ME and TSCE programs and the PLC. Two primary teacher leader activities include: (a) coaching a teacher candidate each year, and (b) supporting the nonprofit's after-school tutoring program for at least 1 of the 5 years. Other teacher leader activities are selected based upon the needs of the school and in consultation with school leadership. The PLC serves as a context for collaborative selection, planning, and reporting on teacher leader activities, in addition to individual conferences with the program director.

Toward the beginning of the school year, each EMS proposes 3–6 specific teacher leader activities in writing to the program director, describing in detail the anticipated activities (i.e., Teacher Leader Plans), after discussion with school leadership. The program director consults with the project's Leadership Team and collaboratively refines with each EMS a plan for specific teacher leader activities to accomplish across that school year. Check-ins related to progress across the school year are included in both PLC meetings and individual conferences. PLC meetings also include time for EMSs to collaborate on these activities, as there are often multiple EMSs implementing similar efforts. This collaborative planning time aims to cultivate: support for individuals, productive brainstorming on shared ideas, and positive working relationships between EMSs, who because they are in schools across the district would not otherwise interact. Each EMS provides documentation at the end of each year of this work in a Teacher Leader Record.

The project's timeline is shown in Table 1, and at the time of this study the EMSs had completed Year 1, including the Teacher Leadership & Coaching and Number & Operations courses, eight PLC meetings, and individual mentoring. In addition to the fore-described focus of the PLCs, during Year 1 there was protracted emphasis on developing student identity in mathematics with collective reading and discussion of "The impact of identity in K-8 mathematics teaching: Rethinking equity-based practices" (Aguirre et al., 2013). Individual mentoring included the program director conducting classroom observations using the Standards-Based Learning Environment Observation Protocol (Tarr et al., 2008) as a guide, along with other planned and emergent one-on-one meetings. Due to the pandemic, all class sessions and meetings occurred virtually and synchronously.

Data Collection and Instruments

All participants completed a Teacher Leader Record (TLR), documenting various aspects of their teacher leader activities across the year. Quantitative data were also collected from all participants via a survey of mathematics coaching practices (Coaching Practices Survey [CPS], Yopp et al., 2019). Qualitative data were gathered through individual interviews of eight randomly selected participants, as well as three focus group interviews of the others. All data were collected at the end of Year 1 and using virtual means, due to the pandemic.

The TLR provides a template for descriptive responses around the four aspects of content, duration, frequency, and outcome for each teacher leader activity. For this study, only the aspect of content is included as data. The content section includes a detailed description of the teacher leader activity and the rationale for implementation, including what exactly the activity was and why they chose to do it.

The CPS is designed to capture the extent to which a coach uses certain practices related to instructional coaching in mathematics that were drawn from coaching models in the extant literature (Yopp et al., 2019). The instrument contains 20 items and uses a 7-point Likert type scale, with a higher rating indicating more self-report of particular coaching practices (ranging from very descriptive of my coaching to not at all descriptive of my coaching). This collection of 20 items exhibits good internal consistency (Cronbach's alpha estimated at 0.81).

All individual and focus group interviews were approximately 1 hour in length. Both interview protocols include questions about their teacher leadership and coaching. The prepared questions provided a starting point, with the interviewer asking questions for elaboration. The interviews were audiotaped and transcribed for analysis.

Data Analysis

The research team includes four university professors and the project's program director, collectively holding expertise in a variety of methodologies, along with two doctoral students. The analysis of the TLR focused on the content of the teacher leader activities, which largely involved examination for frequency and description of activities and clustering into categories when possible. Data from the CPS were dichotomized for analysis in order to identify practices that are descriptive or not of participants' mathematics coaching. For an item, if the response was descriptive at all (rating of 7, 6, or 5) it was assigned a 1, and the other responses of not descriptive or equally not descriptive/descriptive (rating of 4, 3, 2, or 1) were assigned a 0.

Four members of the team analyzed the qualitative data. Line-by-line open coding was used to analyze each of the individual and focus group interview transcripts, while focusing on particular segments of data aimed at addressing the research questions. This coding generated numerous meaning units (i.e., embedded coherent and distinct meanings), with this process support and documented in the software program NVivo. Applying constant comparative methods (Corbin & Strauss, 2008), those meaning units were then compared across participants as the research team reduced the data, by comparing and refining the units. As the researchers reached consensus, the team collapsed and renamed coded meaning units until they collectively determined final shared themes. For example, coded meaning units around barriers to teacher leader efforts, such as those associated with the COVID-19 pandemic and lack of teacher buy-in, were collapsed to form the theme constraints in teacher leadership.

Results

Presented first are the findings addressing the research question focused on the ways in which the EMSs were providing teacher leadership as reported in the TLR, followed by their self-reported coaching practices in the CPS. Then, results for the second research question are shared, specifically the navigations related to their teacher leader efforts as illuminated in the individual and focus group interview data.

Service as Teacher Leaders and Coaching Practices

Data were drawn from the TLR and CPS to answer the research question related to how participants provided teacher leadership, including self-reported coaching practices. All provided teacher leadership in a number of ways, with each reporting details of 3–6 distinct teacher leader activities, dependent upon the scope and scale of each activity. These efforts were in addition to the required

activity of each coaching a teacher candidate, serving as a classroom mentor teacher and/or university coach, with a total of 27 teacher candidates impacted.

The analysis of the TLR shows that over one-third (n = 10) of the EMSs supported the nonprofit's after-school tutoring program. This support was driven by the needs of the after-school tutoring program, based upon consultation with the program's leaders. The EMSs' initial efforts largely focused on collecting and organizing tools and resources to support remote learning during the COVID-19 pandemic, then broadened to include curriculum analyses with revisions. All of this work had an intentional focus on supporting mathematical content that students were concurrently learning in their classrooms. The curriculum analyses involved careful review of the existing guidelines and materials for all grade levels used in after-school tutoring sessions, starting in August and spanning the entire school year, and providing feedback on how to: increase student enjoyment, engagement, and cognitive demand during instruction; implement tasks promoting problem solving, reasoning, and justification; and utilize more manipulatives and tools to improve conceptual understanding. Further, the EMSs provided additional resources and supplements to that curriculum, with the continued aim of increasing rigor, conceptual understanding, and enjoyment of mathematics.

Additional teacher leadership was evident via the analysis of the TLR. Eleven of the participants led mathematics-focused professional development of some kind for fellow teachers at their schools (e.g., PLC, grade level planning sessions, district-wide and school-wide workshops). The content of this professional development largely focused on mathematics pedagogy learned through project experiences, including: (a) Cognitively Guided Instruction (CGI) frameworks for problem types and solution strategies, along with principles for instruction, (b) elements of effective instructional tasks, and (c) equity and access for all learners. Ten formally coached novice teachers at their schools, in addition to coaching a teacher candidate. In this coaching, they were interacting with novice teachers in ways that aligned with the project's emphasis of building teacher capacity through implementation of the cognitive coaching cycle.

Additional teacher leader activities focused on outreach to parents and families. Twelve EMSs facilitated a Math or STEM Community Event for families and students in their respective schools. Twelve led workshops or created resources for parents focused on mathematics as a direct response to remote learning struggles or language barriers (e.g., instructional videos, bilingual resources) or content largely focused on the mathematics pedagogy learned through project experiences (e.g., CGI framework for problem types and solution strategies). While the fore-mentioned categories were the most frequently reported, the EMSs engaged in a number of other mathematics-focused activities. Examples include co-presenting at national conferences, serving on leadership teams within the school district, creating original content for use with teachers and students, facilitating after-school boot camps or tutoring for students, and writing grants to procure resources. Notably, these data illuminate the different types of teacher leader activities that the EMSs as informal teacher leaders initiated or created for themselves, coupled with their concurrent and primary position as teacher of students.

The participants were engaged in coaching in several ways, and a descriptive analysis of data from the CPS provides insights into their specific mathematics coaching practices. Since these participants were informal teacher leaders and serving as EMSs in a variety of ways, with their coaching focused on both teacher candidates and colleagues, these descriptive data illuminate variability and provide contrast with those who serve in a formal instructional coach role and primarily support teachers. The analysis shows that three participants rated 18 of the 20 items as descriptive of their coaching practices and at the other extreme, four participants rated five or fewer of the 20 items as descriptive. Twenty of the 27 participants rated 10 or more items as descriptive of their coaching practices, with seven participants rating fewer than 10 items. The distribution of the dichotomized data is near normal with a negative skew.

An item analysis comparing the identification ratings indicates that 56% of the items are descriptive of mathematics coaching practices. Interestingly, the four lowest-rated items, which were rated by

26%, 26%, 30%, and 33% of the participants as descriptive of practices, all focus on collaboration and communication with the principal or other school administrators about mathematics coaching (e.g., discussing the school's vision for mathematics instruction, progress being made toward that vision, and teachers' needs; collaborating to ensure a clear message about effective mathematics instruction). This seems to indicate that the principal or administration at these school sites is not actively involved in the coaching practices of the participants. Since the participants are informal teacher leaders, with a focus in part on coaching teacher candidates, it is not surprising that there is variability in how much they work with school leaders in their coaching responsibilities. In contrast, Table 2 shows the seven highest-rated items, which 70% or more of the participants indicated as descriptive of their coaching practices.

Navigating Teacher Leader Efforts

To address the second research question about navigations related to their teacher leader efforts, several themes emerged from the analysis of the individual and focus group interview data, including: constraints in teacher leadership, practicing agency in teacher leadership, and affordances of informal teacher leader role. Illuminative quotes are provided, with the interview source (individual = II or focus group = FG) and participant ID (P#) noted in parenthesis.

Constraints in Teacher Leadership

In their efforts as teacher leaders, including coaching, constraints were associated with a number of factors, namely the COVID-19 pandemic and variable teacher buy-in, with teachers having limited autonomy when it comes to decision-making around mathematics curriculum and instruction, not viewing themselves as "math people," and generally resisting change. Challenges related to the pandemic were linked to coaching of teacher candidates and delivery of professional development to fellow teachers. One described her frustration in working with a teacher candidate as:

> It's the situation we are in right now. I wasn't able to teach my student teacher the real way that we teach because of the Coronavirus. I kept telling her, "This is not how we teach normally, we normally have groups" . . . And she's like, "Okay, so how do you normally teach?" (II, P18)

In addition, providing professional development for peers held challenges linked to the pandemic, as one shared:

> I had to do it digitally . . . And I had to make some adjustments in the way that I provide professional development with keeping the teachers engaged . . . The biggest challenge is: How can I keep everybody engaged? It's the end of the day, everybody is tired. How can I present this information in a way that's fun and applicable to what they're doing in their classrooms? (II, P20)

Relatedly, one described how difficult it had been to implement teacher leadership in the manner emphasized in the project, lamenting in his work with teachers: "It is challenging to develop relationships when everything has got to be on a Zoom call" (FG, P17).

Additional challenges were evident in their work as teacher leaders, especially teacher buy-in, as teachers within the school district feel they have limited autonomy when it comes to decisions about

Table 2. Most prevalent coaching practices on the CPS (≥70%).

3. I coach teachers on needs that I observe in the teacher, even when the teacher is unaware of these needs
5. I always make sure that coaching conversations with mathematics teachers are grounded in the mathematics content
9. I try to provide the teachers I coach with an understanding of how the mathematics they teach supports learning beyond the grade level they teach
11. I encourage the teachers I coach to reflect on similarities and differences among mathematics topics in the curriculum
12. I help teachers plan their lessons
16. I reflect on state assessment data to identify curriculum areas that need to be strengthened
19. I encourage teachers to set personal improvement goals for mathematics

curriculum and instruction. Within the context of a prescribed instructional model characterized as gradual release, where the teacher demonstrates procedures and strategies followed by students emulating and practicing them, one questioned, "It's just that balance of when do teachers get to bring in their personal teaching skills? Or, when do they get to bring in the way that they want to teach math to their class? So, I think that's one of the challenges that I've seen [in my teacher leadership]" (FG, P8). An additional constraint in affecting change in their teacher leadership was linked to fellow teachers not having confidence in their mathematical knowledge. One described this as: "They [teachers] claim that they're not math people. That they didn't understand it as a kid. They hated math growing up, and it has never been their strong suit" (FG, P24). A final challenge encountered by the EMSs in their work as teacher leaders includes teachers' general unwillingness and concerns when it comes to change. Said one: "I think the teachers are used to doing things a certain way, and people are afraid of change . . . This year, especially with COVID and hybrid teaching, and this and that. It was a lot of people are just done" (II, P16).

Practicing Agency in Teacher Leadership

In navigating these constraints, the EMSs described ways of being agentic as teacher leaders, such as: focusing on incremental changes, with variations in degree; keeping a "long haul" view; and building better relationships with peers to affect change, within both formal and informal spaces. Across the data, there was some mentioning of school administrator support. Central to these navigations was the network of EMSs within the project, relying heavily on their collaborations with one another and drawing support from the community of learners.

In their efforts to practice agency in navigating constraints, they spoke of focusing on incremental changes within the existing teaching and curriculum. One shared her perspective on this as, "Just doing small steps, I can't tackle everything at once" (FG, P12). Another explained how she tried to affect change through the simple act of sharing instructional tasks with peers "that can be easily tweaked for other teachers, so they can use it, too" (II, P1). Another described continuous weekly reminders for colleagues during co-planning on the importance of children's use of representations and their own invented solution strategies, saying: "I think it's been really eye-opening by just continuing to bring it up every week at grade level [planning meetings]" (FG, P11). This participant, a special education teacher who co-teaches students, described scale-up changes related to the integration of CGI, as well as working with her principal. She shared:

> I told my principal, I am looking to do 2 days of just [CGI] word problems. That still gives us 3 days to do the [school district]-type teaching, but I need for her to be open to allow us to start with, if nothing else, just kindergarten and first grade. Because then, in the next 2 or 3 years, we'll start seeing it increased in all the other grade levels.

This focus on incremental changes was also linked to the project duration of 5 years, prompting some to have a "long haul" view when it comes to affecting change and navigating challenges. Said one: "I think that a solution is that we have time. You know this is a 5-year program, and so I'm looking very forward to how things change and develop. I'm really growing and getting stronger this year. This year, all of us have to get better and get stronger, and so I think that that'll help us in the years to come" (FG, P17). A similar perspective of long-haul view with incremental changes, including those that are readily accessible by teachers, was described by others. One, who is at a school where there are four teachers in the project, shared:

> The good thing is we have numbers. There are four of us. And, we have the support of our principal. And so, we really did try to not just make it so overwhelming because we already did an outline for next year, and just kind of make it applicable that they [teachers] could easily implement it in their classroom right away. And, get bits and pieces since we have, you know, 4 more years left in the program. (II, P16)

Developing collaborative, trusting relationships that fostered teacher responsiveness was also described as important for practicing agency in their teacher leadership. For example, while focusing on incremental changes, one described the salience of creating these relationships with peers through formal and informal interactions:

> Building that solidarity with them [fellow teachers] through transparency, so they feel like we're all in this together. Let's take it step-by-step, so we understand it better. If you have questions, let's chat. If you need help putting together like a center or something, let's share what we have with each other, we're all good resources to use. So, building that network and extending that network of relationships between the grade levels and the different teachers, and fostering those connections has been very vital—still a big work in progress. Like I said, still have a long way to go, but definitely have more people on board by the end of the year than we did at the beginning of the year when we started the program. (FG, P24)

Another described this developing of relationships through opening up conversations during his facilitation of a PLC, sharing:

> We as a group don't necessarily always want to go to PLC when it's time . . . And so, I gear the PLC to be more of a conversation than a task . . . We started engaging, and then I felt like they were in the groove, and they were enjoying themselves. (FG, P6)

In navigating their work as teacher leaders and shoring up agency, they also described the importance of the network of EMSs in the project. They leaned into one another for support, along with sharing ideas and resources. They especially connected this to the experiences in the project's PLCs. One said:

> It's been helpful, the PLC group that I'm with, we are frequently texting each other. You know, do you have any ideas for this? Do you have an idea for that? I shared with [project's program director] that, and she set up a posting place for professional development that we've done. So, if I've done a professional development on digital math resources, I can post it there. And, they can redeliver it or vice versa. If I need help with something, if somebody has any ideas, or if they've done it before, if that's in the available space, I can go back and look. So, just reaching out to other teachers. (II, P20)

Affordances of Informal Teacher Leader Role

In navigating their teacher leader efforts, the interview data illuminate affordances of their informal capacity, coupled with their primary role of teaching students. In their work as teacher leaders, they spoke of credibility and understanding, as they themselves are classroom teachers. Said one:

> I feel like, since we're teachers and we're in the trenches with them, we can kinda of take that as part of the training [for colleagues] and not make it so much like, you know, overwhelming or whatnot. But, it [being a classroom teacher] could be actually helpful for them to buy into it. (II, P16)

Another, describing how fellow teachers respect her intentionality as a classroom teacher, illuminated how this makes teachers more open to her ideas. She gave the example of sharing an instructional task with peers, elaborating: "So if I'm willing to use it (instructional task) and something different. Then, maybe others will be, too, since I'm more on the picky side" (II, P1).

Linked to their primary role as teacher of students, they were having a growing influence on fellow teachers. Their positioning gave them credibility, and fellow teachers were observing and seeking out their expertise, both in formal and informal ways. Said one:

> Leadership activities I've done, people have shown real interest . . . a [school-wide] newsletter I've been sending with tips and things I learned from the math course. So, people are kind of curious, like, "What is the thing you're doing?" And, they're wanting to know, and they're kind of seeing me as, even in my [grade level] team, they're seeing me as a math person. And, so they just ask me, "How do you teach this with your kids because my kids are not really getting that?" So, that impact is slowly spreading in my team and throughout the school." (II, P16).

Another participant, who is a push-in mathematics support teacher in classrooms, talked about her advocacy and increasing influence, particularly in informal ways ("It's kind of by accident" FG, P11). She is implementing CGI in her small group instruction, and her co-teachers are noticing the benefits and wanting her to support more children. She describes a teacher's response as:

> "You're doing something really cool, these kids could do that, and these kids could use that." I'm like, "Well, would you like to learn how to do it?" And, she's like, "Yeah." So, she's like, "You have to teach me." So, it's pretty

cool to see the impact that we have, just when we're trying things out, and people are seeing it and liking it, and knowing that it's good for kids.

Discussion and Implications

Given the notable variability of EMS preparation programs and of the roles and responsibilities these professionals assume, more research is needed on differing program models and EMSs highly varied ways of working, especially as teacher leaders and associated navigations. These findings will provide important research-based considerations for program improvement and replication that are essential in scaling-up the use of these professionals. Our project provides an example of a preparation program guided by standards and research, with the findings illuminating the types of teacher leader efforts the EMSs were choosing and initiating, and how they were practicing agency in this work. Further, having a primary, concurrent role of teacher of students afforded opportunities and influence with their fellow teachers that they might not have had otherwise. It should be noted that these EMSs were selected based upon a rigorous process and are subsequently participating in a rigorous preparation program, which contrasts with the too often practice of those who are simply the most effective mathematics teacher appointed as a teacher leader or coach.

The TLR provides insights into their ways of working as teacher leaders, including coaching teacher candidates and novice teachers and facilitating professional development for fellow teachers at their school sites focused on the mathematics pedagogy emphasized in the project. In these efforts, they were serving as a more knowledgeable other for a community of practice within a school, aiming to influence teachers and the school's mathematics program as a whole (Campbell & Malkus, 2014). In their coaching, they reported implementation of the cognitive coaching cycle, with a body of research showing the positive outcomes of this approach (Edwards, 2021). When considering studies documenting the work of EMSs (Campbell & Malkus, 2011; Chval et al., 2010; Mudzimiri et al., 2014; Whitenack et al., 2014), there is some contrast. For example, it seems their role as teacher of students and informal teacher leader lent itself to directing their efforts toward supporting parents and families. Further, though a required teacher leader activity for 1 of the 5 years of the project, it is notable that 10 of them chose in the first year to support the nonprofit's after-school tutoring program.

Data from the CPS illuminate variability in specific mathematics coaching practices, including those most were and were not using. Notably, the least descriptive practices are related to communicating and collaborating with school administration, which is not surprising given the participants are informal teacher leaders and in part coaching teacher candidates. However, this finding provides implications for project experiences and how this aspect could be improved, since as conceptualized teacher leader activities, including coaching, are to be selected and implemented in consultation with leadership at their school sites. Notably, the extant literature (Campbell & Griffin, 2017; Hopkins et al., 2017) reveals factors related to developing school capacity and sustainability when it comes to coaching and instructional reforms, with school leadership understanding and involvement as important. It will be interesting to see if this pattern of data in the CPS changes over time, as the project participants become more established and hopefully confident in their role as informal teacher leader and seek more collaboration with school leaders. In contrast, their specific capacity as informal teacher leader held affordances, which were illuminated in their descriptions of how their primary role as teacher of students provided understanding and credibility when it came to their work with colleagues, opening the door for greater influence. These findings especially add to the research, illuminating how EMSs navigate their teacher leader efforts particularly in the understudied area of those in an informal role.

Adding to the findings of others (Blazar, 2020; Hannan & Russell, 2020; Hashim, 2020; Hopkins et al., 2017), the results provide insights into how the EMSs were navigating their teacher leader efforts through practicing agency as they encountered contextual constraints, leaning into particular strategies and the community of learners provided in the project. The challenges posed by the COVID-19

pandemic were pervasive, as those were trying times for teachers. Further, they encountered teacher resistance to change for a number of reasons. These findings illuminate areas for support related to EMSs' work as teacher leaders and the importance of developing agency so challenges are strategically met and with strong self-efficacy and persistence (Bartell et al., 2019). Notably, our project aims to take up powerful vehicles for supporting agency through meaningful, intentional, and sustained professional learning experiences (National Council of Teachers of Mathematics, 2020) and a community of support through a teacher network (Bartell et al., 2019), where the EMSs can explore, grapple with, and seek to address tensions in their work (Reagan et al., 2016). The findings of this study are promising, given that after only 1 year the project EMSs are already drawing from the network of support and being strategic in navigating difficulties in their teacher leader efforts.

When considering the ways the EMSs were engaging as teachers leaders, strongly evident is reciprocity with mutual benefits for all partners, including the university, school district, and community-based nonprofit organization (National Association for Professional Development Schools, 2021). The findings show the numerous and varied ways they were supporting several stakeholders, including fellow teachers, novice teachers, teacher candidates, students, school administrators, parents and families, and community partners. For example, the coaching of 27 teacher candidates strengthens the university-school partnership, contributes to high quality clinical experiences for teacher candidates, and situates the teacher candidates in a hiring pipeline at the high-need urban schools, addressing a teacher shortage. Further, their coaching of novice teachers supports induction into the profession, with a body of research showing that individual mentoring of those in the first 3 years of teaching is critical for retention (Maready et al., 2021; Ronfeldt & McQueen, 2017; Smith & Ingersoll, 2004). Lastly, their work supporting community connections (e.g., after-school tutoring program, math community events) and intentional interactions with parents and families foster key relationships and shared responsibility for students' learning in mathematics (National Council of Teachers of Mathematics, 2021).

These data collected 1 year into a 5-year professional development project offer important implications for the project itself and associated research. The results provide insights into areas needing support, namely improved collaboration of EMSs and school leadership, with the PLCs having an increased emphasis on fostering these key relationships in the development and implementation of teacher leader activities. The findings also illuminate needs related to the tensions the EMSs were facing in their teacher leader efforts. The continuance and scale-up of intentional time and space for the EMSs to collectively consider and analyze challenges in their work as well as strategies for successful navigation are crucial. As professionals, it is fundamental the EMSs have the ability to shape their teacher leader endeavors in ways that draw upon existing research, understandings and capabilities developed in the project, and analysis of their own practices. As an example and connected to the findings of this study, top-down policies and practices aimed at standardization, such as prescribed curriculum, instructional models, and pacing guidelines for content and standards, are typically well-intended and have good elements. Yet, they can pose contextual constraints for affecting teacher change (Bartell et al., 2019), and EMSs should navigate these with agency by drawing upon worthwhile and evidence-based aspects while bringing their own professional autonomy, voice, and expertise. Continued inquiry into the ways the EMSs are practicing agency coupled with meaningful supports provided via the project, along with the dilemmas and affordances related to their specific role as informal teacher leader, is important.

Finally and significantly, this project intentionally supports EMSs who are from underrepresented populations and working in schools that serve students who have been historically marginalized and underserved in mathematics education. The school sites serve 91% students of color and selection criteria for the project ensured the EMSs are a diverse group, with 70% identifying as nonwhite. This is significant as increasing research shows students of color benefit from having teachers of color (Carver-Thomas, 2018; Egalite & Kisida, 2018; Yarnell & Bohrnstedt, 2018). In addition, for the teacher candidates coached by the EMSs, program data show 75% are from underrepresented groups (nonwhite) in the teaching profession, contributing to the much needed diversity of the teacher

workforce as recent data show 78% of public school teachers in the USA are White (National Center for Education Statistics, 2022). Equity and access within mathematics education are through-threads of this project. Within this context, continued research across the 5 years of the project provides a unique and exciting opportunity to follow the trajectory of the EMSs as informal teacher leaders in their development as agentic advocates for effective and equitable mathematics instruction.

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